# Simultaneous Operations: The Key to Speed and Efficiency for Unconventional Oil and Gas

Multi-well pad drilling has emerged as a means to reduce overall costs.

## THE GAME HAS CHANGED…AN EMPHASIS ON SPEED AND EFFICIENCY

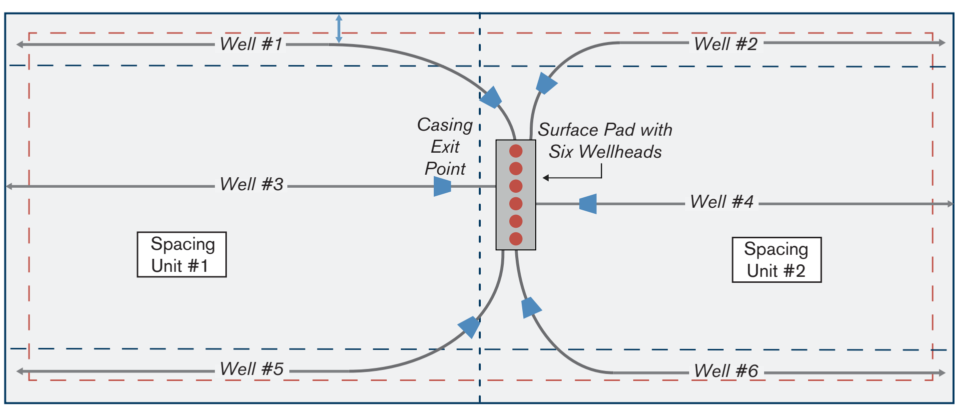
The push to cost-competitively exploit large, unconventional resource plays has driven exploration and production ("E&P") companies to build lean and efficient operating models, with a focus on speed and cost management. Driven by the need to quickly, cost-effectively and safely exploit unconventional resource plays, many E&P operators — particularly those in domestic shale plays — have moved from single-well drilling to pad drilling. Multi-well pad drilling has emerged as a means to reduce overall costs by allowing for shared construction costs, equipment and facilities, while reducing the overall pad footprint.

## TRADITIONAL MULTI-WELL PAD DRILLING

A pad-based drilling approach coupled with horizontal drilling techniques allows multiple well bores to be drilled, completed and produced from a single surface pad location (Figure 1). In traditional multi-well pad drilling, the operator drills multiple well bores from one pad before moving the drilling rig to another site and mobilizing completion crews to the pad. All well bores are then completed in one batch (Figure 2).

This batch approach enables teams to reduce surface disturbance as fewer pads are required and surface facilities (e.g., separators, tank batteries) are shared across multiple wells. More importantly, batch processing is effective in helping operators secure scarce or long-lead time services, materials (e.g., proppant, water) and other equipment (e.g., separators, pump jacks).

**FIGURE 1: MULTI-WELL PAD LAYOUT FOR SIX-WELL PAD**



While batch processing has been used by manufacturing companies to successfully drive down costs by leveraging economies of scale, it also raises a series of other issues that need to be addressed to ensure effective cost management — namely, lengthening the time from spud to initial production and tying up working capital.

Batch processing also causes other significant challenges for asset teams. In the six-well pad scenario described in Figure 2, six wells must be drilled and completed

**FIGURE 2: BATCH PROCESSING APPROACH FOR MULTI-WELL PADS**

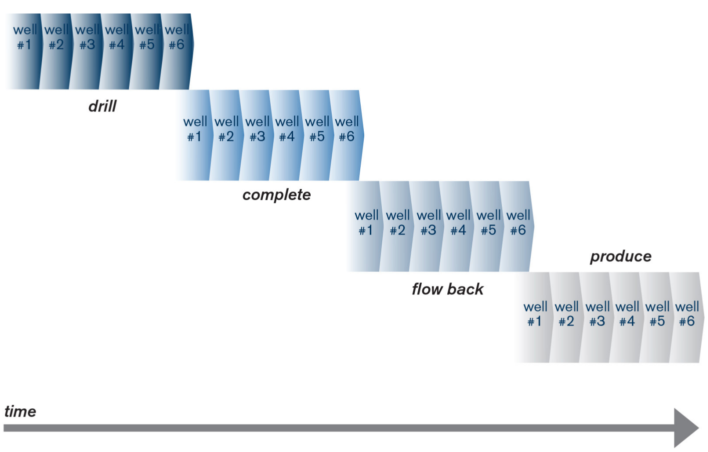
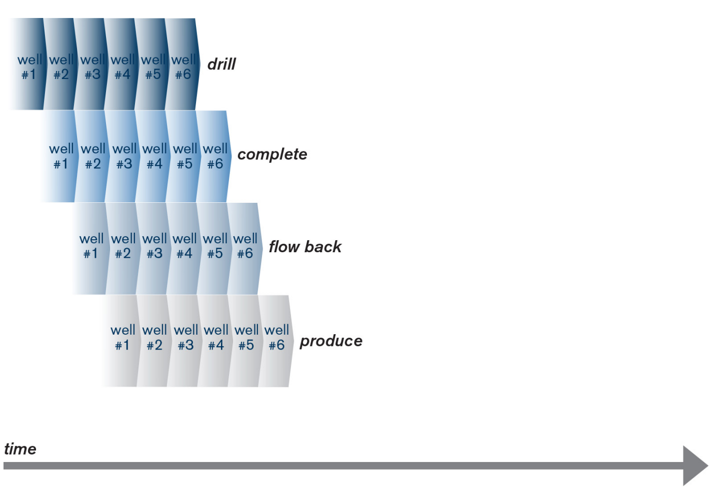



**FIGURE 3: CONTINUOUS FLOW APPROACH FOR MULTI-WELL PADS**



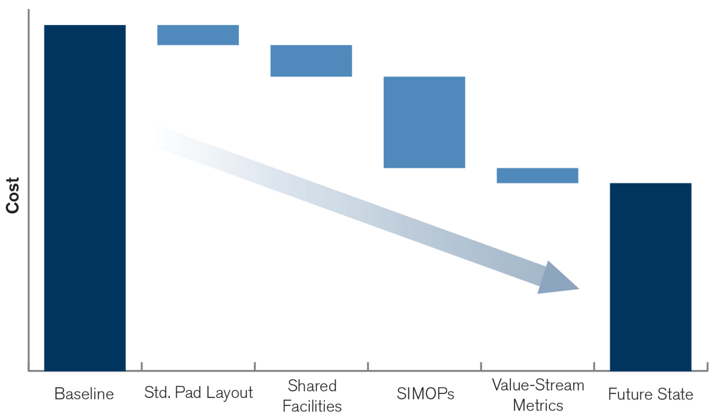

before the results of the first well are known. This delays commencement of production, as well as analysis of data from early wells, to improve well design and completion techniques that optimize drilling and completion performance, cost and production cycle time of subsequent wells. The extended spud-to-first production translates to large working capital requirements as drilling and completion capital for early wells is spent in advance of the early wells coming online.

## IMPLEMENTING CONTINUOUS FLOW

As multi-pad drilling techniques have advanced, E&P operators have tackled the challenges of longer cycle times and increased working capital outlays by leveraging the concept of continuous flow. Continuous flow is based on the idea of "just-in-time" manufacturing — produce only what is needed exactly when it is needed for the next process. Continuous flow addresses the problems inherent in batch processing and has significant benefits, including significant reduction in working capital outlay, shorter cycle times, smoother material demand and earlier identification of errors or quality problems. Just as in a factory environment, where multiple manufacturing processing steps occur simultaneously (e.g., cutting, stamping, assembly, testing, shipping), continuous flow can be achieved in E&P operations by drilling, completing and producing wells from the same pad at the same time. Leading E&P operators are applying this factory-style approach and successfully implementing continuous flow on multi-well pads. In order to achieve continuous flow, four components must be in place — standard pad designs, standard equipment and facilities, simultaneous operations ("SIMOPs") and cross-functional performance metrics.

Standardizing pad designs within each operating area is the first component that must be in place for continuous flow. Multi-well pads, by design, enable the use of shared surface facilities, which consolidate and reduce the cost of production and gathering equipment across multiple wells. Standard pad layouts allow the development of a repeatable process and use of standard equipment, improve safety, and provide opportunity for continuous process improvement.

**FIGURE 4: SAMPLE BENEFITS FROM CONTINUOUS FLOW**




With standard pad layouts in place, operators can standardize equipment and facilities. This includes designs for drilling rigs, hydraulic fracturing equipment, tank batteries and other on-site equipment. Standard pad designs increase scheduling flexibility by utilizing interchangeable equipment across locations, which reduces scheduling variability and resulting equipment delay. In turn, inventory for key equipment and materials can be reduced, and maintenance activities can be conducted more cost efficiently.

A key component that allows for continuous flow is implementing SIMOPs. With SIMOPs, as soon as a well is drilled, the drilling rig skids to another well location on the same pad and begins drilling while the previous well is completed. In this scenario, drilling, completions, flow back and production operations are all occurring at the same time on the same pad. For instance, while Well No. 4 is being drilled, Well No. 3 is being completed, Well No. 2 is in flow back and Well No. 1 is producing in steady state. As noted in Figure 3, overall cycle time is significantly reduced, reducing working capital and shortening the time from spud to first production. Standard pad designs are imperative when performing activities concurrently because they provide a safe means to approach SIMOPs. It is extremely important for operator and service company personnel to be keenly aware of their surroundings and the operations of fellow workers nearby. Without a standard pad design the location of activities may change from pad to pad, limiting the ability of crew members to know where their fellow hands are and what they are doing. Non-standard pad design limits the ability to effectively manage safety hazards in a repeatable process, because each unique design and layout brings its own challenges and hazards. The final component required is cross functional performance metrics. Traditional performance metrics alone (spud-to-TD cycle time, completion stage costs or pipeline construction costs) typically focus on functional efficiency and effectiveness rather than the entire process. For asset teams to truly implement successful continuous flow, they need to focus on end-to-end value stream metrics, such as spud-to-first production cycle time and cost and pad-to-pad cycle time. By measuring performance across the value stream, an asset team is able to eliminate functional silos and have a single, coordinated goal. This coordinated alignment around cross functional goals sets the stage for continuous improvement and continued reductions in total cycle time and cost. While SIMOPs helps E&P operators realize large cost savings and cycle-time reductions, value stream metrics lock in the savings by preventing asset teams from reverting back to the siloed approach that optimizes the function at the cost of the whole.

## CONTINUOUS FLOW SPEEDS TIME TO PRODUCTION AND ENHANCES CAPITAL EFFICIENCY

Continuous flow yields benefits along two dimensions — shortening the time from spud to first production and reducing drilling and completion costs. Companies that have successfully implemented continuous flow have seen 30-40 percent reductions in both cost and cycle time. During the transition from single-well drilling to multi-well pad drilling, cost and cycle time will continuously decrease. Initially, savings are a result of standardizing pad layout, which allows for shared facilities, further driving down costs. While those two components reduce cost, the real benefits (both realized savings and avoided costs) stem from continuous flow as a result of SIMOPs. Asset teams are often challenged by the desire to stop after implementing multi-well pad construction and facility standardization. Unless the team is driven by value stream metrics and incented appropriately, the evolution to continuous flow and greater savings will not be achieved.

The cost savings from a standard pad layout are derived from effectively consolidating activities into a central location. Multi-well pads, by design, result in fewer in-field rig moves, which increases drilling rig uptime and, in turn, the number of wells drilled. Additionally, effective standardization of the pad layout enables even faster rig moves. One large U.S. independent successfully reduced its rig-move cycle time by 35 percent, saving $120,000 per rig move in day rates and heavy hauler services. Across a fleet of 10 rigs, this unlocked capacity to drill an additional seven wells per year (see Figure 5).

Once standard multi-well pads are in place, the next step of reducing facilities costs is achievable. For example, in the case of our illustrative six-well pad, the operator is able to use two sets of surface equipment rather than six and eliminate $1 million in surface facilities ($250,000 per well). Replicated across a drilling program, the cost savings begin to significantly grow.

In addition to financial benefits, multi-well pad drilling techniques are generally viewed favorably by most landowners and regulatory agencies and result in greater maintenance efficiencies for lease operators and maintenance crews. Since multi-well pads allow shared surface facilities and multiple wells to be tied back to a common surface footprint, the overall ground disturbance and truck traffic are significantly reduced.

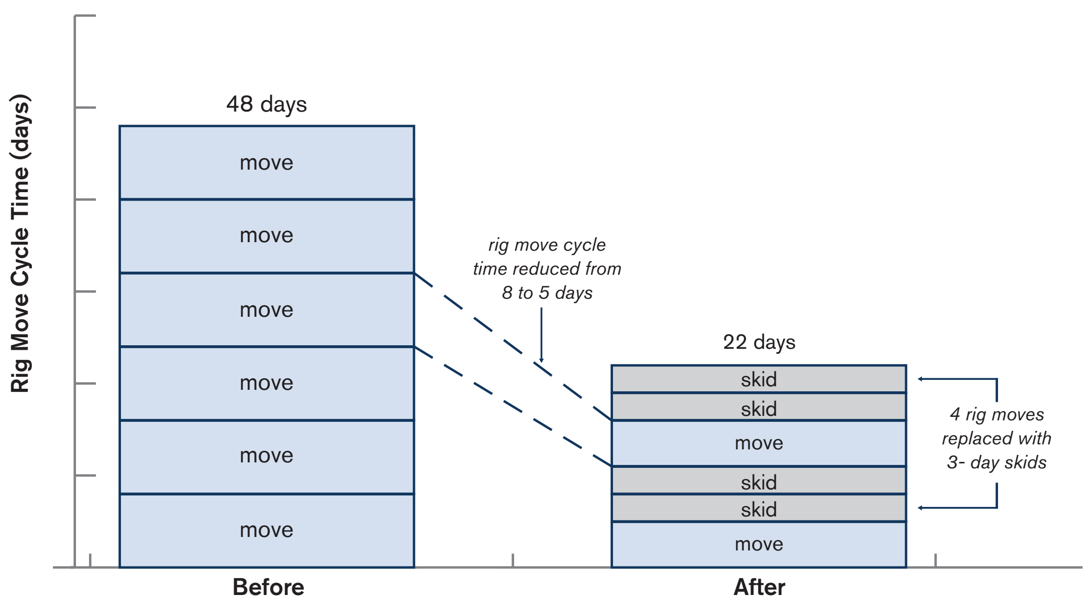
**FIGURE 5: RIG MOVE CYCLE TIME REDUCTION**

| | 1-Well Pads | 2-Well Pads |
|---|---|---|
| Spud - Rig Release | 40 days | 40 days |
| Rig - Move Time | 8 days | 3.7 days |
| Spud - Spud | 48 days | 43.7 days |
| Days per Year | 364 days | 364 days |
| Annual Wells per rig | 7.6 wells | 8.3 wells |
| Rig Fleet | 10 rigs | 10 rigs |
| *Total Fleet Capacity* | *76 wells* | *83 wells* |

*capacity to drill 7 additional wells with same rig fleet*

| | 1-Well Pads | |
|---|---|---|
| Move | Days | Type |
| On to Well 1 | 8 days | Move |
| Well 1 to 2 | 8 days | Move |
| Well 2 to 3 | 8 days | Move |
| Well 3 to 4 | 8 days | Move |
| Well 4 to 5 | 8 days | Move |
| Well 5 to 6 | 8 days | Move |
| *Move Days / Pad* | *48 days* | |
| *Avg. Days / Move* | *8 days* | |

| 6-Well Pads | |
|---|---|
| Days | Type |
| 5 days | Move |
| 3 days | Skid |
| 3 days | Skid |
| 5 days | Move |
| 3 days | Skid |
| 3 days | Skid |
| *22 days* | |
| *3.7 days* | |



## IMPLEMENTING CONTINUOUS FLOW MEANS TACKLING NUMEROUS CHALLENGES

The primary challenge for teams seeking to implement SIMOPs is determining how to manage concurrent drilling, completions and production activities on the same pad in a safe manner. Teams should carefully conduct HAZOP studies and assess risks while challenging current work processes and pad and equipment designs. Many operators have found the need to modify pad layouts, drilling rig designs and hydraulic fracturing equipment designs in order to safely co-locate crews, conduct all operations concurrently and minimize downtime associated with moving equipment around on location.

Standardizing pad designs themselves can prove to be a challenge. Construction crews are traditionally measured and provided incentives based on construction cycle time and cost. Accordingly, there is a mindset to optimize the pad design for each unique location in order to "build it faster" or "build it cheaper" or "build it like the driller wants." Deploying cross-functional teams and focusing on end-to-end value stream metrics will help change these paradigms.

Every operator in a new shale play has faced the predicament of lease expiry in non-HBP (held by production) acreage positions. Lease expiry can present a challenge to multi-well pad drilling as the elapsed time between pads is significantly longer. Teams must have clear line of sight to lease expiry across its portfolio of locations and seek out alternatives in which a single pad reaches multiple spacing units and aggressively pursue efforts to collapse spud-to-first production cycle time.

Additionally, many operators have found the need to redesign Authorization for Expenditure (AFE) processes. The use of shared facilities, crews and equipment across multiple wells causes cost allocation challenges. Equipment and construction cost are incurred with the first well before AFEs are prepared and approved for subsequent wells. Teams must develop a means to allocate these shared costs to all wells on the pad.

Multi-well pads by nature require large footprints, sometimes in excess of 20 acres, and can cost upwards of $400,000 to construct. As a result, construction crews must manage much larger and more complex projects than they are typically used to. More importantly, due to their large footprint, it can be challenging to locate multi-well pads, while avoiding surface constraints such as wetlands, grasslands and contentious landowners. Therefore, it is important for teams to clearly identify pad design constraints, as well as the surface constraints of its acreage position upfront and manage this information throughout field development.

Operators first deploying SIMOPs find managing drilling, completions, flow back, and sometimes production and construction crews on a single pad at the same time challenging. All of these operations occurring concurrently naturally results in more people, more trucks and more equipment — increasing complexity. In order to best manage these risks, operators should develop pad site controls and new roles, such as traffic control and SIMOPs coordinator.

Lastly, SIMOPs requires robust well planning and scheduling processes. With all of these concurrent activities, it is important to reduce variability as much as possible. This requires having crews, permits and equipment in the right place at the right time. Teams need clear line of sight to current performance and transparency into the priorities of well planning and scheduling.

## FACTORY-STYLE DRILLING DRIVES LONG-TERM SUCCESS IN UNCONVENTIONAL RESOURCE PLAYS

Most North American E&P operators have found that speed and efficiency in large-scale drilling programs are critical to success in today's unconventional resource plays. Factory-style drilling and completion operations, including SIMOPs, are proving to be the optimal operating model in all major unconventional resource plays including the Marcellus, Haynesville, Bakken, Barnett and Eagle Ford. Many operators, including EnCana, Talisman, Chesapeake, Devon and Hess, have successfully deployed 6, 8, 16, and even 32-well pads, while simultaneously managing uninterrupted drilling, completion, production and gathering operations in a safe and cost-efficient manner. In doing so, these operators have realized a 30-40 percent reduction in total drilling and completion cost. As companies continue to ramp up unconventional operations, they will continue to seek new methods for cost reduction and efficiency gains.

To achieve these benefits, E&P operators must do more than drill multiple wells in batches from a single pad. They must also create continuous flow, which entails standardizing pad designs, standardizing facilities and equipment designs, conducting simultaneous operations, and implementing cross-functional value stream performance metrics.

Creating continuous flow through SIMOPs entails tackling certain challenges, including managing a new set of safety risks, lease expiry issues, larger pad construction projects, and implementing robust planning and scheduling processes.

In doing so, operators will be able to drill more wells with fewer rigs through faster spud-to-spud times and fewer rig moves. They will realize benefits faster and propagate best practices quicker through shorter spud-to-first production cycle times. Shorter spud-to-first production cycle times will also yield lower working capital requirements. Lastly, they will realize drilling and completions cost reduction through standard pad and equipment designs, as well as shared facilities and equipment.

## FIGURE 6: CHARACTERISTICS OF BATCH FLOW AND SIMULTANEOUS OPERATIONS

| Batch Flow | Continuous Flow |
|---|---|
| Drill all wells, complete all wells, flow back and produce from all wells | SIMOPs - Concurrent drilling, completions,wm flow back and production activities |
| Shared facilities and equipment | Shared facilities and equipment |
| Fewer in-field rig moves | Fewer in-field rig moves |
| Reduced spud-to-spud cycle time | Reduced spud-to-spud cycle time |
| Extended spud-to-first production cycle time | Reduced spud-to-first production cycle time |
| Large amounts of working capital required | Reduced working capital requirements |
| Performance metrics focused on functional excellence (drilling, completions, production) | Cross-functional performance metrics |
| Greater access to scarce crews and long-lead time equipment | Requires robust planning and scheduling |

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